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ABSTRACT TITLE: Computer simulations of laser-tattoo interaction with different laser pulse lengths

AUTHOR LISTING: D. D.-M. Ho, R. A. London, M. E. Glinsky, and D. A. Young

ADDRESS: Lawrence Livermore National Laboratory, University of California,
P. O. Box 808, Livermore, CA 94550, U. S. A.
Tel: 510-423-9786
Fax: 510-423-9208
e-mail: ho1@llnl.gov

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BIOGRAPHY: Dr. Ho has made contributions in high-current particle accelerator physics, laser-cooling of heavy-ion beams, high-current beam propagation and focusing, radiation conversion from ion beams, hohlraum physics, hydrodynamic implosions, stratospheric negative-ion chemistry, and transport and reactor physics in stellarators. His current research interests are laser-tissue interactions, laser-tattoo removal, laser-assisted stroke treatment, and heavy-ion fusion.

BRIEF ABSTRACT: Laser tattoo removal is more efficient with decreasing pulse lengths for the same laser energy. This is because at 10 ns, the energy in the tattoo particle is neither thermally nor stress confined. When the pulse length is reduced to 1 ns, the tattoo particle can reach higher temperatures and the generation of the stress wave is more efficient because the energy is thermally confined. At 10 ps or shorter, the generation of the wave becomes most efficient because the energy is both thermally and stress confined. Our simulations are performed using the hydrodynamics code LATIS with a material strength and failure model.

ABSTRACT

Laser tattoo removal is more efficient with decreasing pulse lengths for the same laser energy. When the tattoo particles are heated, cavitation bubbles are formed around the particles and can cause damage to the dermis. Understanding these processes via numerical modeling is the subject of this presentation.

The graphite tattoo particle used in our modeling is surrounded by water. Our basic modeling tool is the laser-tissue interaction code LATIS (LAser-TISsue). This one- or two-dimensional, time-dependent program includes the processes of laser propagation, thermal transport, accurate EOS, material strength and failure.

The size of the tattoo particle in our numerical simulations has a diameter of 50 nm which is considerably less than the absorption length of laser light. The particle is therefore heated uniformly and the temperature profile of the particle is nearly flat. Despite this nearly flat profile, strong stress waves can still be generated inside the particle.

For a 10 ns pulse, the energy in the tattoo particle is neither thermally nor stress confined. If the energy absorbed by the particle is 1 pJ, then the maximum temperature and tensile stress reached in the particle are about 250 C and 10 bar, respectively. If the pulse length is reduced to 1 ns, the energy in the particle is marginally thermally confined. The maximum temperature and tensile stress reached are about 1300 C and 200 bar, respectively. For the 10 ps pulse, the energy is now both thermally and stress confined and the maximum temperature and tensile stress are about 2200 C and 4000 bar, respectively. The size of the cavitation bubble formed around the tattoo particle ranges from 15 μm to 30 μm as the pulse length changes from 10 ns to 10 ps.

By including the material strength and failure model, we show how much damage is done to both the tattoo particle and the surrounding tissue.

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